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WESTERN SPRUCE BUDWORM DAMAGE EVALUATION

1978

Progress Report No. 1

by

David G. Holland
Gene Lessard

Forest Insect and Disease Management
State and Private Forestry
Southwestern Region, Forest Service, USDA
517 Gold Avenue, SW
Albuquerque, New Mexico 87102

I. INTRODUCTION

The western spruce budworm (Choristoneura occidentalis Freeman) is a major defoliator of Douglas-fir (Pseudotsuga menziesii) and true fir (Abies spp.) in the western United States. Outbreaks of this insect can cause severe defoliation with subsequent tree mortality, top-kill, and radial growth loss. The extent and severity of damages to host trees has not been documented in the Southwest. Reliable damage information is needed to help forest managers determine the most effective, economical, and environmentally acceptable approaches to managing the western spruce budworm.

In 1978, a long-term damage assessment project was initiated on the Carson National Forest to determine damages resulting from an outbreak that began in 1975. This report summarizes methods used to assess tree damages and the results of the sampling for 1978.

II. OBJECTIVES

The purpose of this evaluation is to assess damages to Douglas-fir, true fir, and spruce caused by the western spruce budworm on the Carson National Forest, New Mexico. Specific objectives of the evaluation follow:

A. Growth Loss

1. Determine the amount of growth loss and recovery for three past infestations that occurred from 1922-1966, and the current infestation which began in 1975.

2. Determine if differences in growth loss and recovery occur between site classes and timber size classes.

3. Determine if a relationship of defoliation to radial growth loss can be established for site and size classes.

B. Tree Mortality and Top-kill

1. Determine the amount of tree mortality and top-kill caused by the current budworm infestation.

2. Determine if a relationship of defoliation to top-kill and mortality can be established for site classes and timber size classes.

III. PROJECT AREA

The evaluation areas are located in the drainages of the Rio Fernando de Taos, Taos Ranger District, and Cabresto Creek, Questa Ranger District, Carson National Forest (Figs. 1-5). These areas have had four infestation cycles since 1922. The current infestation was detected in 1975 with noticeable defoliation apparent in drainages

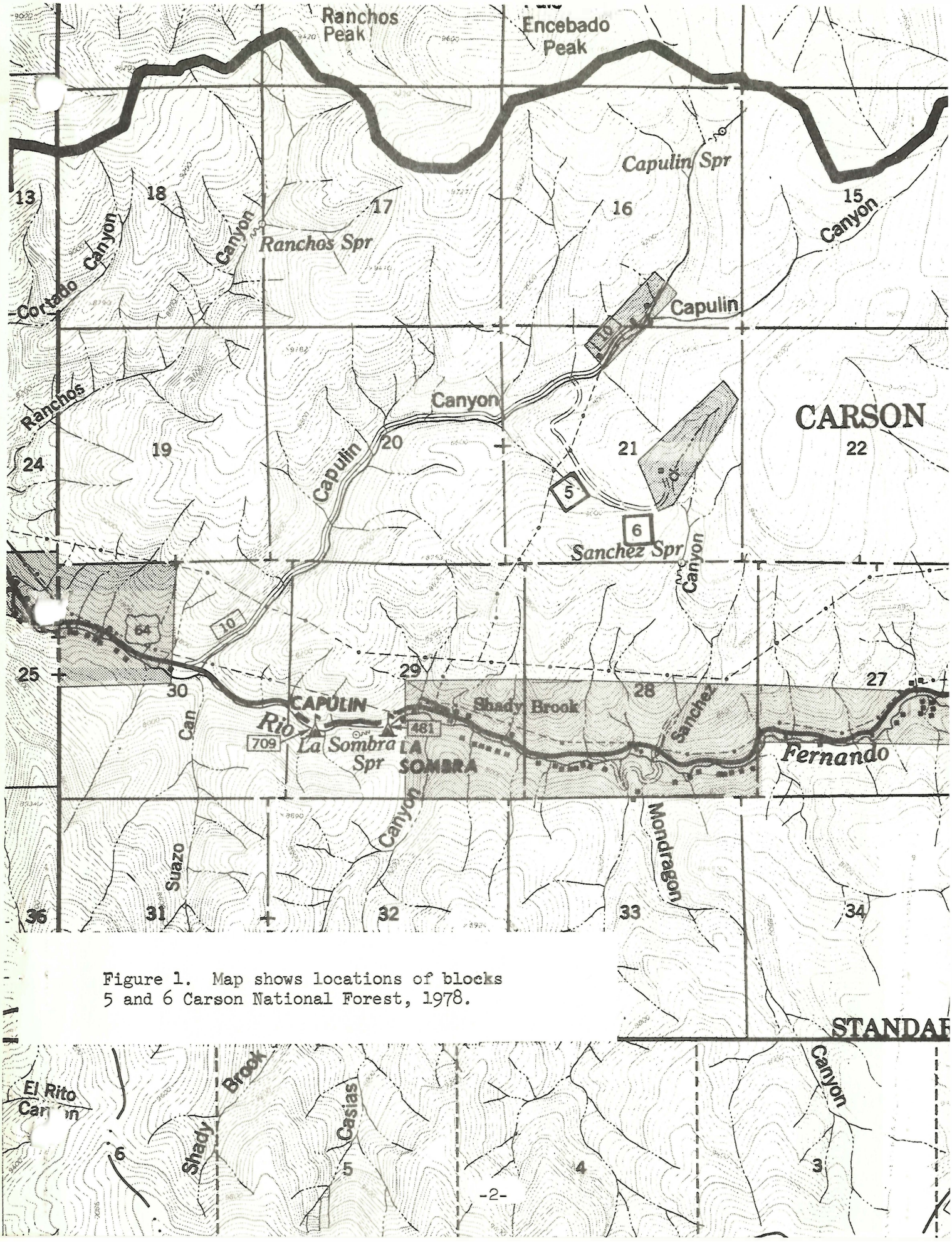


Figure 1. Map shows locations of blocks 5 and 6 Carson National Forest, 1978.

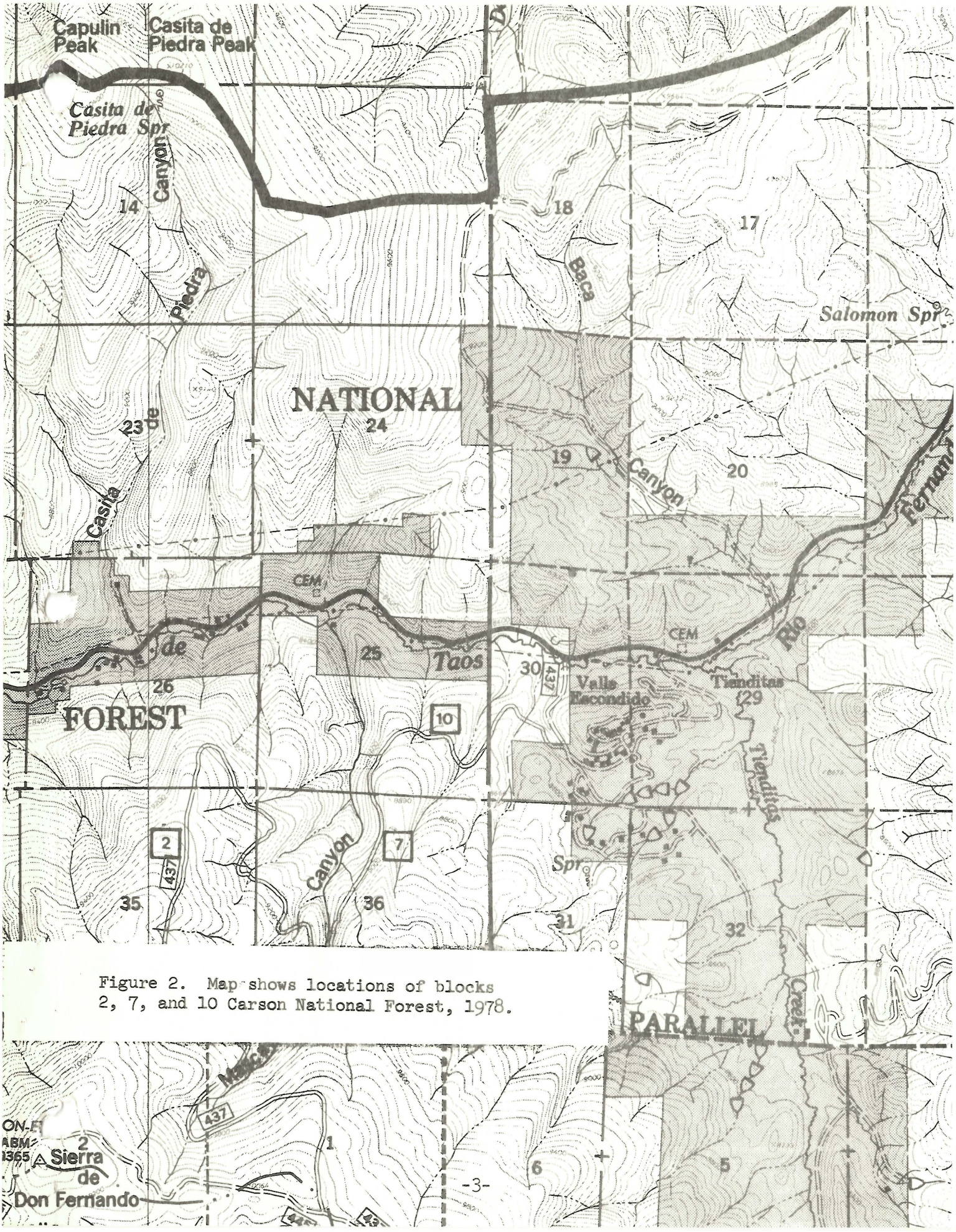


Figure 2. Map shows locations of blocks 2, 7, and 10 Carson National Forest, 1978.

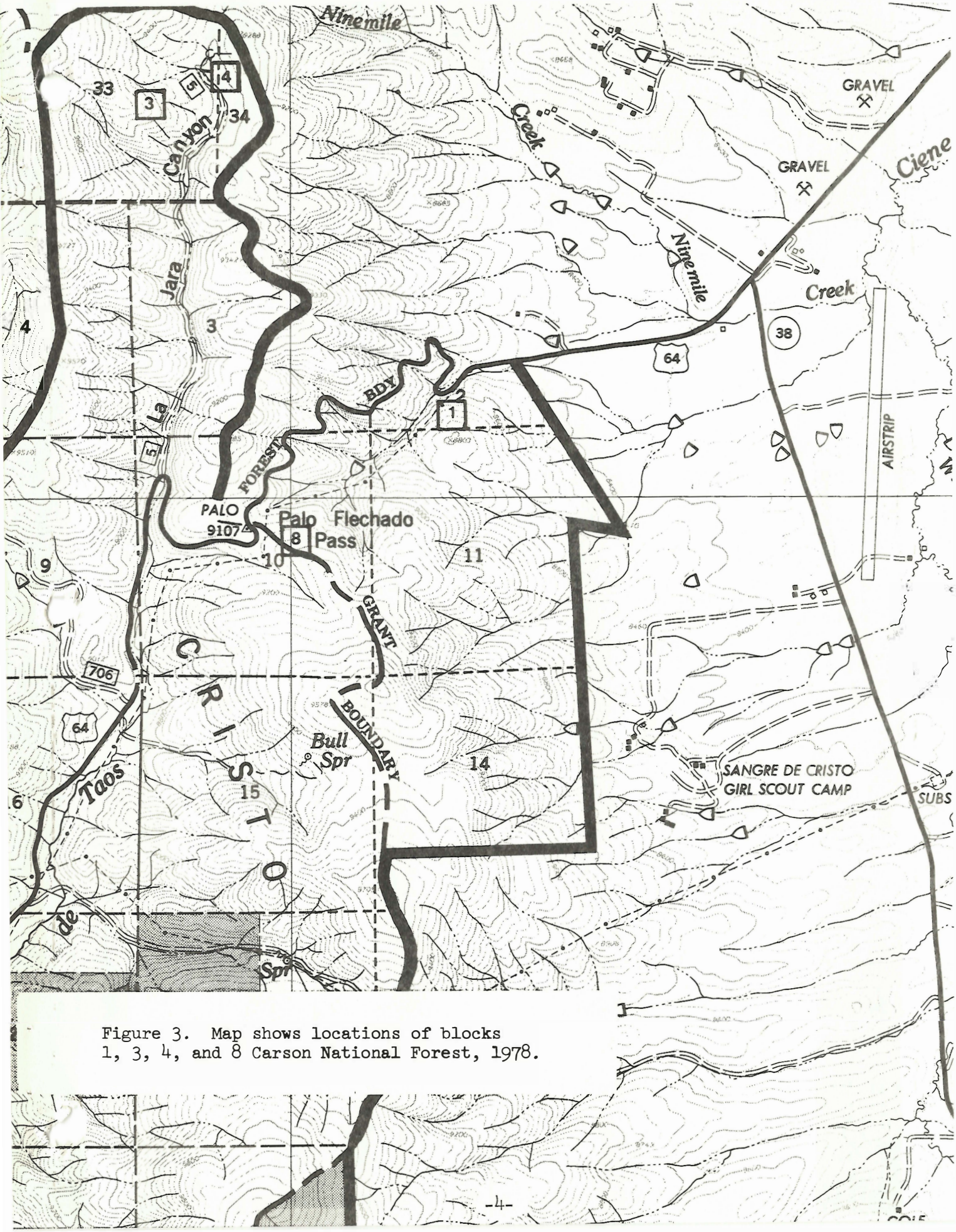


Figure 3. Map shows locations of blocks 1, 3, 4, and 8 Carson National Forest, 1978.

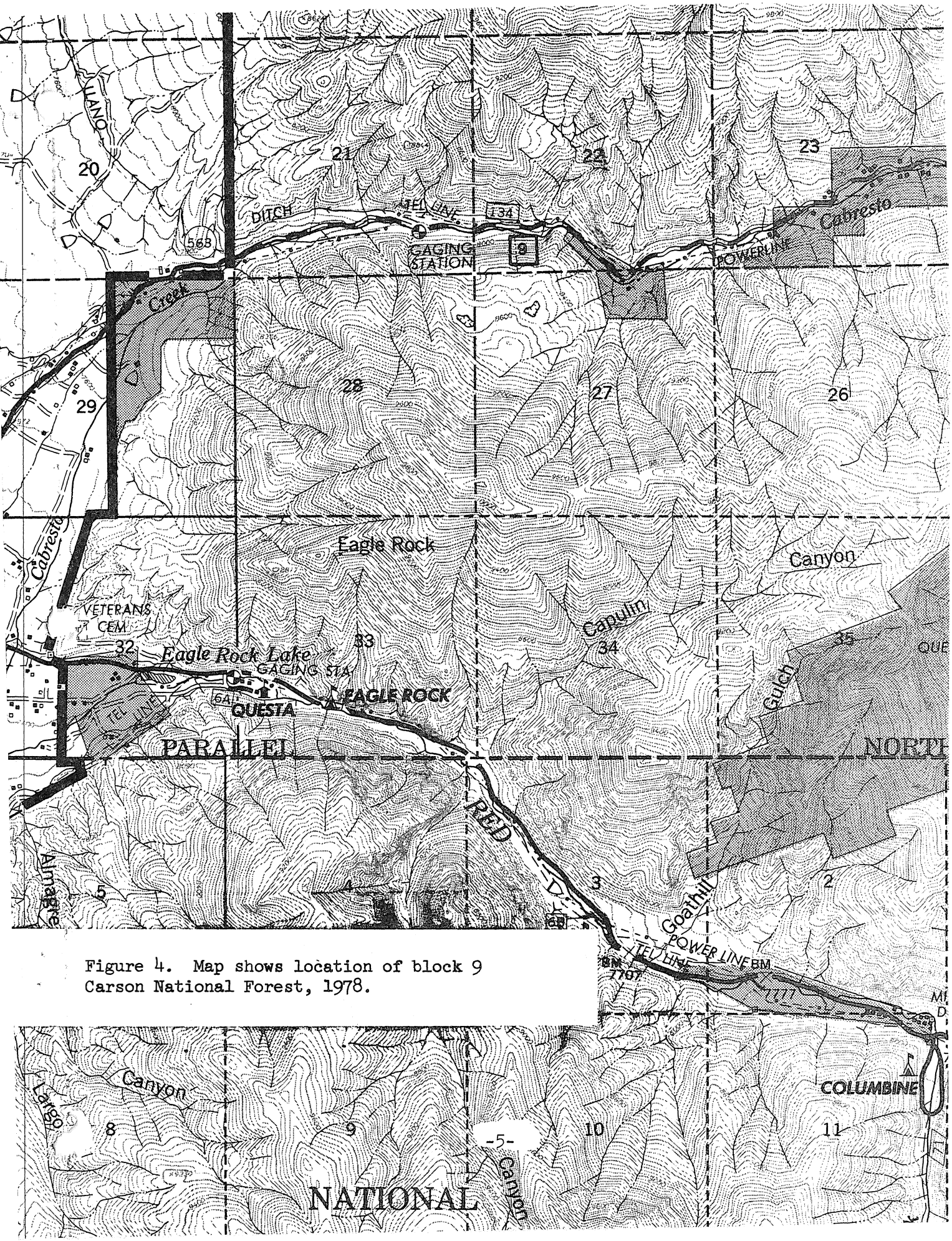


Figure 4. Map shows location of block 9 Carson National Forest, 1978.

Figure 5. Map shows locations of blocks 11 and 12 Carson National Forest, 1978.

of the Rio Fernando de Taos. In 1978, defoliation was classified as moderate to heavy over 15,000 acres. Egg mass data indicate that the outbreak will continue to increase in intensity and size in 1979.

IV. METHODS

A. Block Establishment

Twelve 1-acre blocks were permanently established in June 1978; three blocks in the Cabresto Creek drainage and nine blocks in the drainages of the Rio Fernando de Taos. All blocks were permanently marked using paint and flagging, witness trees, and corner stakes. Blocks were located to provide a representative sample of three site classes and the past infestations. Three Douglas-fir site trees were measured on each block to determine site index. Site class codes were determined from site index values as follows:

Site Class Code	
I	site index 75 or above
II	site index 55-74
III	site index 54 or below

B. Damage Assessment

On each block, all trees greater than 5 inches d.b.h. were sampled. All sample trees were permanently tagged, using block number and tree number. The following information was obtained from each tree:

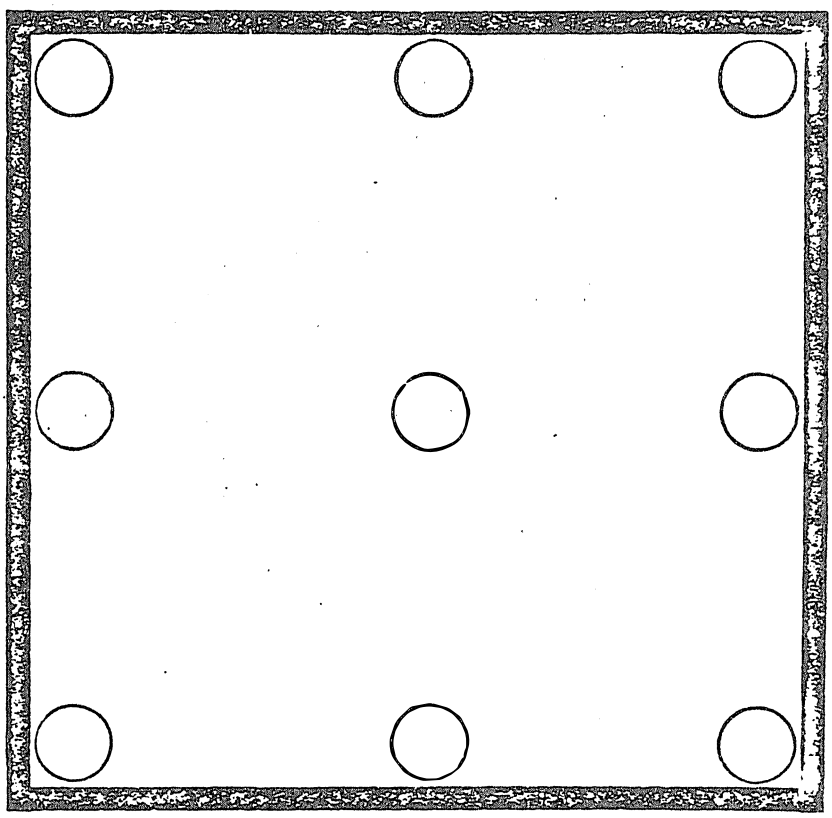
1. Species
2. Height (to the nearest foot)
3. Diameter at breast height (to the nearest 0.1 inch)
4. Top-kill (basal area per acre)
5. Tree mortality (basal area per acre)
6. Percent defoliation
7. Annual growth increment (to the nearest mm)
8. Crown ratio

Also, on each block (Fig. 6), a subsample of 9, 1/100-acre circular fixed plots were established. On these plots, all trees less than 5 inches d.b.h. were recorded. Plot centers were located on a 1.5-chain (90-foot) grid in each block. The following information was obtained from each tree:

1. Species
2. Diameter at breast height (to the nearest 0.1 inch)
3. Trees live or dead
4. Relative defoliation (light, medium, or heavy)
5. Tree height (to the nearest inch)

Figure 6.--Location of 1/100-acre circular plots on 1-acre survey tracts.

Scale is 2" = 100'



C. Defoliation

Defoliation estimates were made on 10 Douglas-fir trees per block using the procedure developed by Carolin and Coulter (1972) and the 6-class system (Parker et al. 1978).

The method described by Carolin and Coulter divides each tree into 3-crown levels (upper, middle, and lower) and a visual estimate of defoliation is made for each level. The midpoint values of the following defoliation classes were tallied:

Defoliation class %	Midpoint value %
0-10	5
11-25	18
26-50	38
51-75	63
76-90	83
91-100	95

Two observers rated each tree. The average of these two values was weighted using the following values: lower crown - 5, middle crown - 3, and upper crown - 1. The average values were multiplied by the assigned weight to give a weighted average per crown level. The sum of these weighted averages for each crown level was divided by 9 to give percent defoliation for the entire tree.

The 6-class system involved sampling 4 apical branches (70 cm in length) from each quadrant at midcrown of each sample tree. In each branch sample, 25 new shoots were examined for current defoliation using the left side of one branch and the right side of another, and so on. Each new shoot was individually examined for defoliation and assigned an index and midpoint value as follows:

Defoliation class %	Index value	Midpoint value
0	0	0
1-25	1	12.5
26-50	2	37.5
51-75	3	62.5
76-99	4	87.5
100	5	100

Plot defoliation was simply the average of the individual tree values. Individual tree defoliation was calculated using the following formula:

$$\% \text{ defoliation} = \frac{(n_1)\ (12.5) + (n_2)\ (37.5) + (n_3)\ (62.5) + (n_4)\ (87.5) + (n_5)\ (100)}{100}$$

Where n_1 = number of twiglets with index value 1

n_2 = number of twiglets with index value 2

n_3 = number of twiglets with index value 3

n_4 = number of twiglets with index value 4

n_5 = number of twiglets with index value 5

D. Growth Loss

On each block, core samples were taken from trees greater than 5 inches d.b.h. Thirty trees were sampled on each block which included 10 Douglas-fir, 10 true fir, and 10 ponderosa pine. Core samples were placed in paper straws for storage and labeled with plot and tree number. Radial growth measurements were done by the Intermountain Forest and Range Experiment Station, Moscow, Idaho, using an Addo System.

E. Seedling and Sapling Mortality

Seedling and sapling (0.1 to 4.9 d.b.h.) measurements were made on each 1/100-acre plot (Fig. 6). Trees with a d.b.h. of 0.5 to 4.9 inches were considered saplings. Trees with a d.b.h. of less than 0.5 inches, or trees less than 4.5 feet in height, were considered as seedlings. Data recorded for each tree included species, d.b.h., height to the nearest inch, live or dead, and a visual estimate of defoliation. In addition to the 1/100-acre plots, a 1-acre seedling block was established in La Jara Canyon, Taos Ranger District, to assess the damage caused by the budworm on planted seedlings.

F. Tree Mortality and Top-Kill

Tree mortality and top-kill were recorded on all blocks. All tree mortality and top-kill due to the present infestation was recorded as such. All tree mortality and top-kill not attributed to the present infestation was recorded as old, and used as a base line for future tree damage assessment.

In 1978, both the incidence of and the amount of top-kill was measured. The length of the dead top, to the nearest foot, was measured with a Relaskop. Top-kill was expressed as the proportion of length of top-kill to total tree height.

Trees have the ability to establish adventitious buds after intense defoliation, thereby providing tree recovery. For this reason, tree mortality and top-kill are difficult to identify. Therefore, all tree mortality and top-kill will be verified for at least 2 years following the initial determination.

G. Population Assessment

1. Larvae

On each block, 25 Douglas-fir trees between 20-40 feet in height were randomly selected for sampling larval density in 1979 through 1983.

2. Egg Masses

Egg masses were sampled by cutting two 70 cm midcrown branches from opposite sides of each of 10 Douglas-fir sample trees per block. Branches were sampled using a pole pruner equipped with a collecting bag. The maximum length and width of each cut branch was measured to calculate foliated branch surface area. Each branch then was individually bagged in 1/4-bushel paper sacks which were transported to the laboratory where they were stored at about 40° F prior to examination.

Foliage from all branches was examined under ultraviolet light for egg masses. Needles bearing egg masses were classed as from current year's foliage or a previous year and kept separate in labeled pill boxes. New egg masses (deposited in the year of sampling) were separated from old egg masses (deposited in the year(s) before sampling) under a stereomicroscope. All egg masses on current year's foliage were classed as new and their characteristics formed the basis for aging those egg masses found on the previous year's foliage.

V. RESULTS AND DISCUSSION

A. Plot Establishment

Site class was used as the primary criterion for block selection. The most frequently occurring site condition was site class II, with the exception of the Cabresto Creek drainage (blocks 9, 11, and 12), where all areas were site class I. Distribution of blocks within the three site classes was done to determine the influence of site conditions on the extent of tree damages and the dynamics of the insect. Site indexes for each block are shown in Table 1.

Table 1.--Site index and class for Douglas-fir on western spruce budworm survey blocks, Carson National Forest, New Mexico.

Location	Block	Site index	Site class
Rio Fernando de Taos	1	52	III
Rio Fernando de Taos	2	55	III
Rio Fernando de Taos	3	72	II
Rio Fernando de Taos	4	81	I
Rio Fernando de Taos	5	75	I
Rio Fernando de Taos	6	57	III
Rio Fernando de Taos	7	60	II
Rio Fernando de Taos	8	70	II
Cabresto Creek	9	80	I
Rio Fernando de Taos	10	65	II
Cabresto Creek	11	90	I
Cabresto Creek	12	78	I

B. Damage Assessment

In 1978, baseline information (tree height, d.b.h., basal area, and stand composition) was collected for all trees within each block. A complete description of the stand was needed to establish a basis from which to describe any changes resulting from damage caused by the spruce budworm. Stand composition data for the blocks and 1/100-acre plots are shown in Table 2 and 3. Additional information regarding basal areas and size classes will be reported in the 1979 progress report.

Table 2.--Species composition for trees greater than 5 inches d.b.h., western spruce budworm blocks, Carson National Forest, New Mexico.

	Stocking density (%)				
Block	Douglas-fir	True fir	Spruce	Pine	Total trees per acre
1	62.9	32.0	4.1	1.0	194
2	87.8	6.5	0.5	5.2	230
3	44.2	12.5	42.3	1.0	104
4	63.9	4.2	31.1	0.8	119
5	29.2	11.1	.0	59.7	72
6	43.9	30.3	.0	25.8	66
7	83.0	2.4	.0	14.6	253
8	71.7	10.8	0.6	16.9	166
9	70.1	3.0	.0	26.9	134
10	50.0	12.1	1.2	36.7	166
11	66.4	15.6	17.2	0.8	128
12	65.1	5.8	28.5	0.6	172
$\bar{x}$	66.5	11.1	9.1	13.3	150.3

Table 3.--Species composition for trees less than 5 inches d.b.h., western spruce budworm blocks, Carson National Forest, New Mexico.

	Stocking density (%)					
Block	Douglas-fir	True fir	Spruce	Pine	Other	Total trees per 1/100-acre
1	33.9	55.9	3.9	.0	6.3	254
2	24.1	45.1	.0	.0	30.8	133
3	11.4	21.7	19.9	.6	46.4	166
4	35.9	4.9	19.4	2.9	36.9	103
5	9.5	27.9	.0	10.4	52.2	222
6	12.6	40.6	.0	.6	46.3	175
7	28.6	7.9	.0	1.4	62.1	140
8	17.9	74.7	.8	1.2	5.4	257
9	49.0	13.5	.0	.0	37.5	192
10	25.7	35.2	1.9	9.5	27.6	105
11	18.6	60.2	3.8	.0	17.4	264
12	27.4	26.5	20.2	.9	25.1	223
$\bar{x}$	23.9	38.5	5.5	2.0	30.1	186.2

C. Defoliation

During an outbreak of the budworm, tree damages result from several years of sustained, heavy defoliation. The relationship of the defoliation to the resultant tree damages is not clearly understood. The objective of measuring defoliation is to determine the relationship of the amount, severity, and duration of defoliation to various degrees of tree damage.

Defoliation for Douglas-fir was determined using the 6-class system and visual estimates and will be related to damage categories in future reports (Table 4).

Table 4.--Percent Douglas-fir defoliation by western spruce budworm, Carson National Forest, 1978.

	Percent defoliation	
Blocks	6-class	Visual
1	47.5	40.3
2	47.0	33.7
3	64.8	50.7
4	69.1	63.4
5	65.6	54.2
6	22.0	28.8
7	54.6	35.9
8	66.5	48.9
9	11.7	6.0
10	70.2	43.4
11	60.7	51.7
12	50.7	35.3

D. Growth Loss

Increment cores were measured for comparing differences in annual growth between host and non-host trees to determine the impact of budworm defoliation on radial growth.

Measurements taken in 1978 to determine management classes and radial growth losses for trees over 5 inches d.b.h. are being analyzed. An attempt will be made to analyze the impact of past infestations on management and site classes, and present these data in the 1979 progress report.

E. Seedling and Sapling Mortality

Damage to seedlings and saplings has never been well documented, but is of importance because these trees represent the timber crop of the future. Baseline data was collected on 1/100-acre plots within each plot to determine the amount of top-kill and mortality. Results for 1978 showed no significant mortality or top-kill to seedlings and saplings resulting from the current infestation.

F. Tree Mortality and Top-kill

Since 1978 was only the third year of the infestation, tree damages were minimal. Results of the 1978 survey indicate no tree mortality and minimal top-kill (Table 5). Information regarding changes in the amount of top-kill and tree mortality, and the relationship to defoliation, will be presented annually in future reports.

Table 5.--Number of top-killed Douglas-fir and white fir trees per acre, Carson National Forest, 1978.

Block	# Trees top-killed	% Trees top-killed	Total # DF & WF trees
1	6	3.3	184
2	7	3.2	217
3	3	5.1	59
4	2	2.5	81
5	7	24.1	29
6	14	28.6	49
7	1	0.5	216
8	7	5.1	137
9	2	2.0	98
10	10	9.7	103
11	2	1.9	105
12	3	2.5	122
$\bar{x}$	5.3	4.6	116.7

G. Population Assessment

Population density estimates were taken to relate insect numbers to defoliation and possibly tree damage. Larval densities were not taken in 1978 because blocks were being established during the sampling period for this stage. Egg mass densities, trend, and predicted defoliation for 1979 are presented in Table 6. Egg mass densities for all blocks indicate the population will continue to increase in 1979.

Table 6.--Western spruce budworm egg mass densities, trend, and predicted defoliation, Carson National Forest, New Mexico, 1978.

Block	Egg masses/ m^2 of foliage	Infestation trend	Predicting 1979 defoliation
1	41.1	Increasing	Heavy
2	11.1	Increasing	Light
3	17.0	Increasing	Moderate
4	34.9	Increasing	Heavy
5	25.1	Increasing	Moderate
6	13.1	Increasing	Light
7	27.3	Increasing	Moderate
8	24.2	Increasing	Moderate
9	3.6	Increasing	Light
10	21.5	Increasing	Moderate
11	15.2	Increasing	Moderate
12	13.6	Increasing	Light

VI. PLANS FOR F.Y. 1979

Data will continue to be collected for top-kill, tree mortality, defoliation, and population assessment parameters in 1979. In addition, data collected in 1978 for radial growth will be analyzed to attempt to determine impact of past infestations on tree growth.

VII. LITERATURE CITED

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Parker, D. L., R. E. Acciavatti, and E. D. Lessard. 1978. Western spruce budworm suppression and evaluation project using carbaryl, 1977. Progress Rep. No. 1. USDA Forest Serv., Southwestern Reg. 136 pp.